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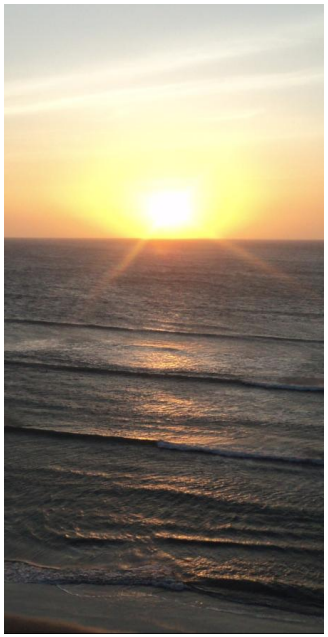
RESEARCH GROUP
HIDRAULIC FOR IRRIGATION

HiDER Madr Tech

Pressurized Irrigation Dealing with Water and Energy Efficiencies



LEONOR RODRÍGUEZ SINOBAS

(leonor.rodriguez.sinobas@upm.es)

- Introduction
- Highlights
  - Automation on operation, control and management
  - Irrigation efficiency
  - Water saving
- Challenges
  - Design, management and operation of collective pressurized irrigation water networks to improve the energy and water efficiencies

INTRODUCTION

SURFACE IRRIGATION METHODS

High Water Use

Low Energy Consumption

Low level of Technology

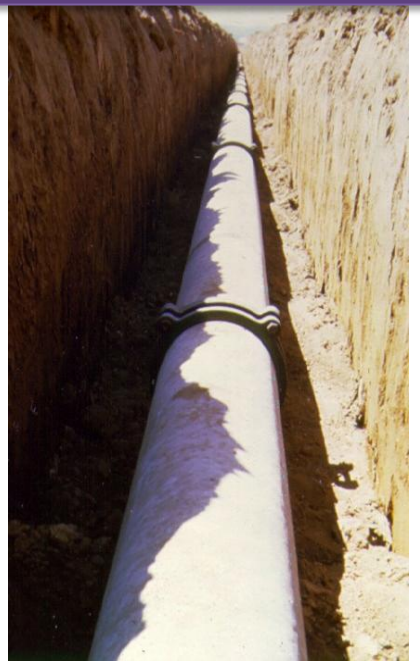
INTRODUCTION

PRESSURIZED IRRIGATION METHODS

Less Water Use

High Energy Consumption

High Level of Technology



HIGHLIGHTS

Automation on operation, control and management

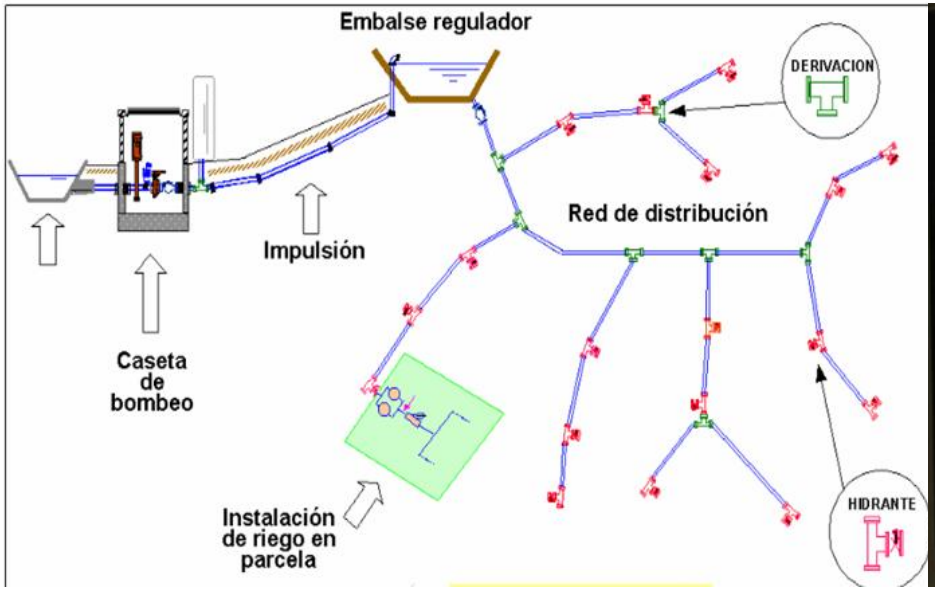
Technology development

- ✓ Pumps, filters…
- ✓ frequency speed drives
- ✓ Electrical-hydraulic valves
- ✓ Flow meters
- ✓ Pressure transducers
- ✓ Remote controllers

HIGHLIGHTS

Automation on operation, control and management

Collective pressurized water networks



Management of irrigation networks

- On demand irrigation
- In turns irrigation

Irrigators file water orders at their Water Users Associations

HIGHLIGHTS

IRRIGATION EFFICIENCY

Andalucian Irrigation Systems

IRRIGATION METHOD	Efficiency (%)
Surface	72.5
Sprinkler	85
Drip	92.5

Source: Inventario de regadíos 2008.

HIGHLIGHTS

WATER SCARCITY SCENARIO

Modernization of irrigation systems

Open-channel systems change to Pressurized pipe systems

HIGHLIGHTS

Objectives for transforming traditional irrigation systems

- **Water savings: competitiveness for diferent water uses, environmental sustainability**
- **Increase water productivity**
- **Increase agriculture competitiveness**

HIGHLIGHTS

Example of modernization

Spain

- Area: 2 000 000 ha
- Cost: 7 400 M €
  (80 % paid by Public Administrations)
- **Water savings : 1 132 hm^3/year**

Water used for irrigation:

- ✓80 % before modernization
- ✓ 65 % after modernization

(Source: MARM, 2002; MARM, 2006)

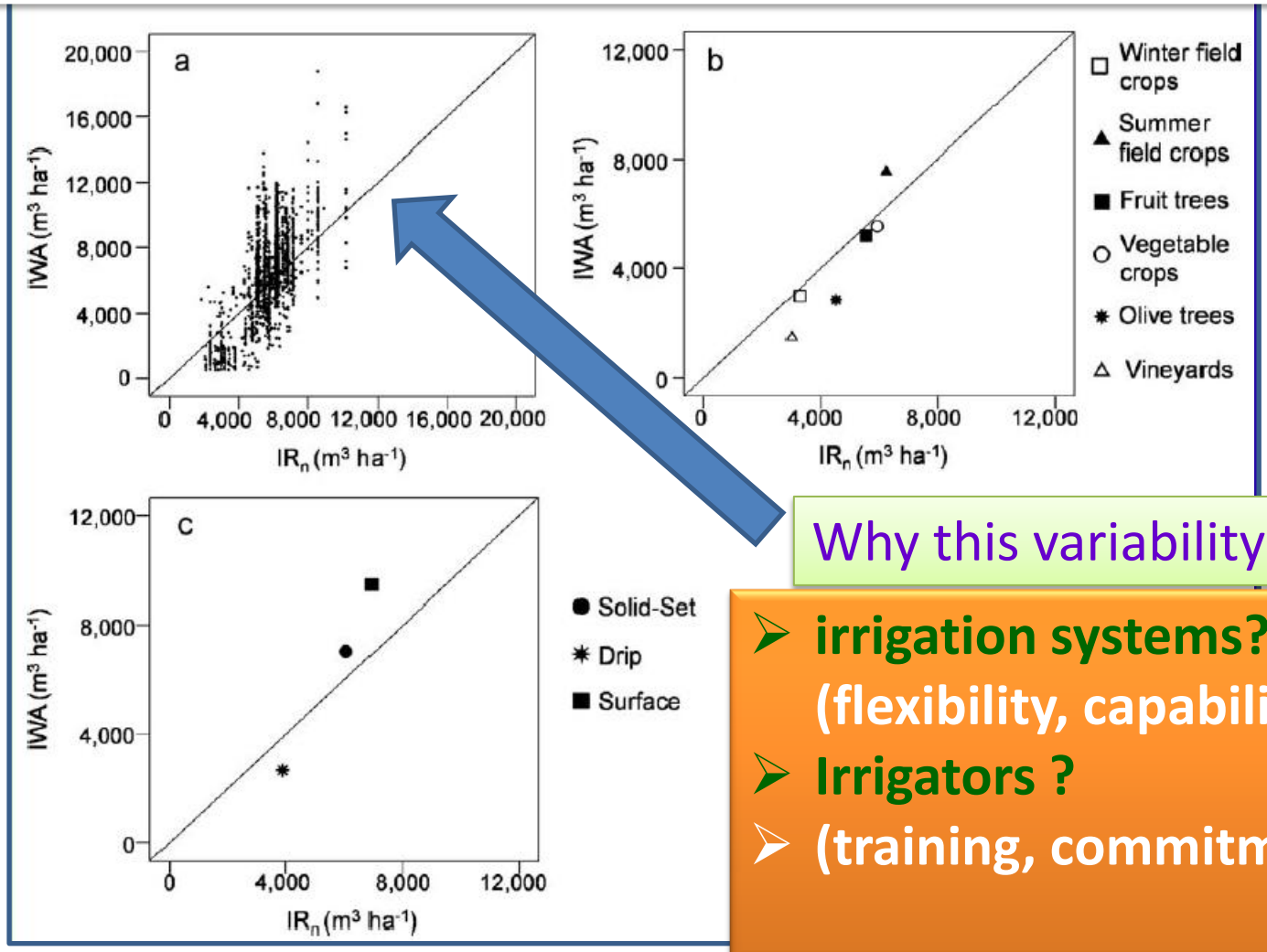
HIGHLIGHTS

PRESSURIZED IRRIGATION IN THE WORLD

Country	Total irrigated area (Mha)	Sprinkler	Micro irrigation	Total sprinkler and micro irrigation	Percentage of total irrigated area	Year of reporting
			(ha)			
USA	21.6	10 900 000	1 200 000	12 100 000	56	2003
Russia	4.5	3 500 000	20 000	3 520 000	78.2	2008
China	55.9	2 634 000	371 000	3 005 000	5.4	2005
India	56.8	1 634 997	864 000	2 498 997	4.4	2007
Spain	3.36	715 102	1 502 327	2 217 429	66.9	2007
Brazil	3.5	1 570 000	340 000	1 910 000	54.58	2004
France	1.575	1 379 800	103 300	1 483 699	94.2	2000
Italy	2.535	1 047 680	365 700	1 413 380	55.8	2000
South Africa	1.6	848 000	296 000	1 144 000	71.5	2004
Saudi Arabia	1.17	716 000	198 000	914 000	78.1	2004
Australia	2.384	524 480	190 720	715 200	30	2000
Canada	0.87	683 029	6 034	689 063	79.2	2004
Mexico	6.2	400 000	200 000	600 000	9.7	1999

HIGHLIGHTS

EXPERIENCES IN WATER USER ASSOCIATIONS FROM THE EBRO BASIN (SPAIN)



Why this variability?

- **irrigation systems? (flexibility, capability)**
- **Irrigators ?**
- **(training, commitment**

HIGHLIGHTS

Water and energy in Andalucian irrigation systems (year 2008)

Irrigation method	Average water use (m^3/ha)	Energy consumption (kW h/ m^3)	Energy consumption (kW h /ha)
Surface	5500	0.06	328
Sprinkler	5000	0.34	1723
Drip	2500	0.51	1264

Source: Corominas 2009.

HIGHLIGHTS

CHANGING ENERGY PRICE SCENARIO

SPAIN

IRRIGATION METHOD	Before 2009		2009		2010	
	ha	%	ha	%	ha	%
Surface	1 973 336	59	1 064 248	31.1	1 043 704	30.6
Sprinkler	802 712	24	765 440	22.4	735 544	21.6
Drip	568 588	17	1 591 616	46.5	1 628 705	47.8
Total	3 344 636	100	3 421 304	100	3 407 953	100

Source: PNR 2001, irrigated areas and crop yield survey .

Reduction of 14 000 ha

CHANGING ENERGY PRICE SCENARIO

SPAIN

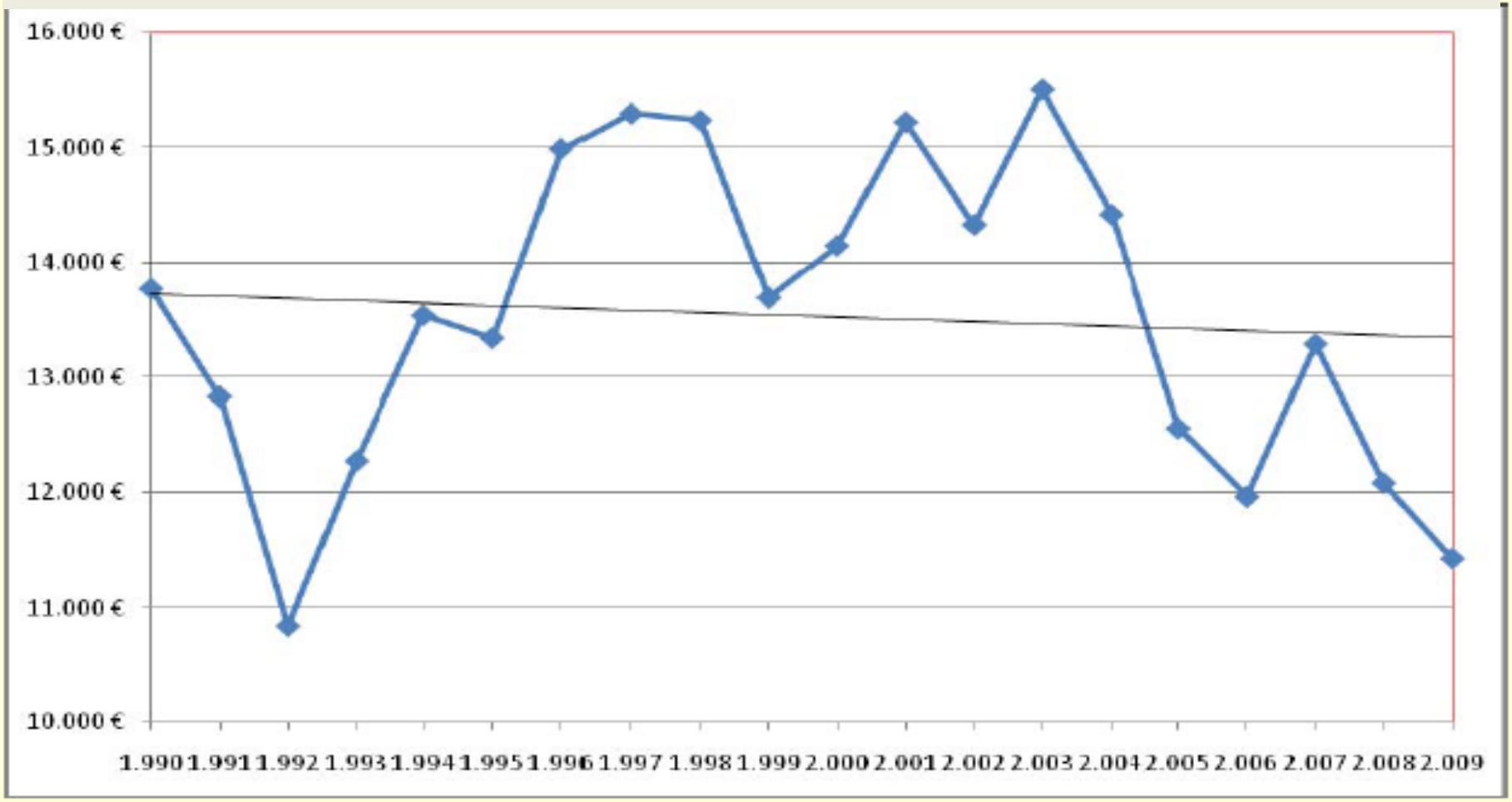
High energy consumption > 600 GWh /year
High power requirement > 500 MW/year

Since 2006, the electrical tariffs have increased:

- ✓455 % the power term
- ✓70 % the energy term

HIGHLIGHTS

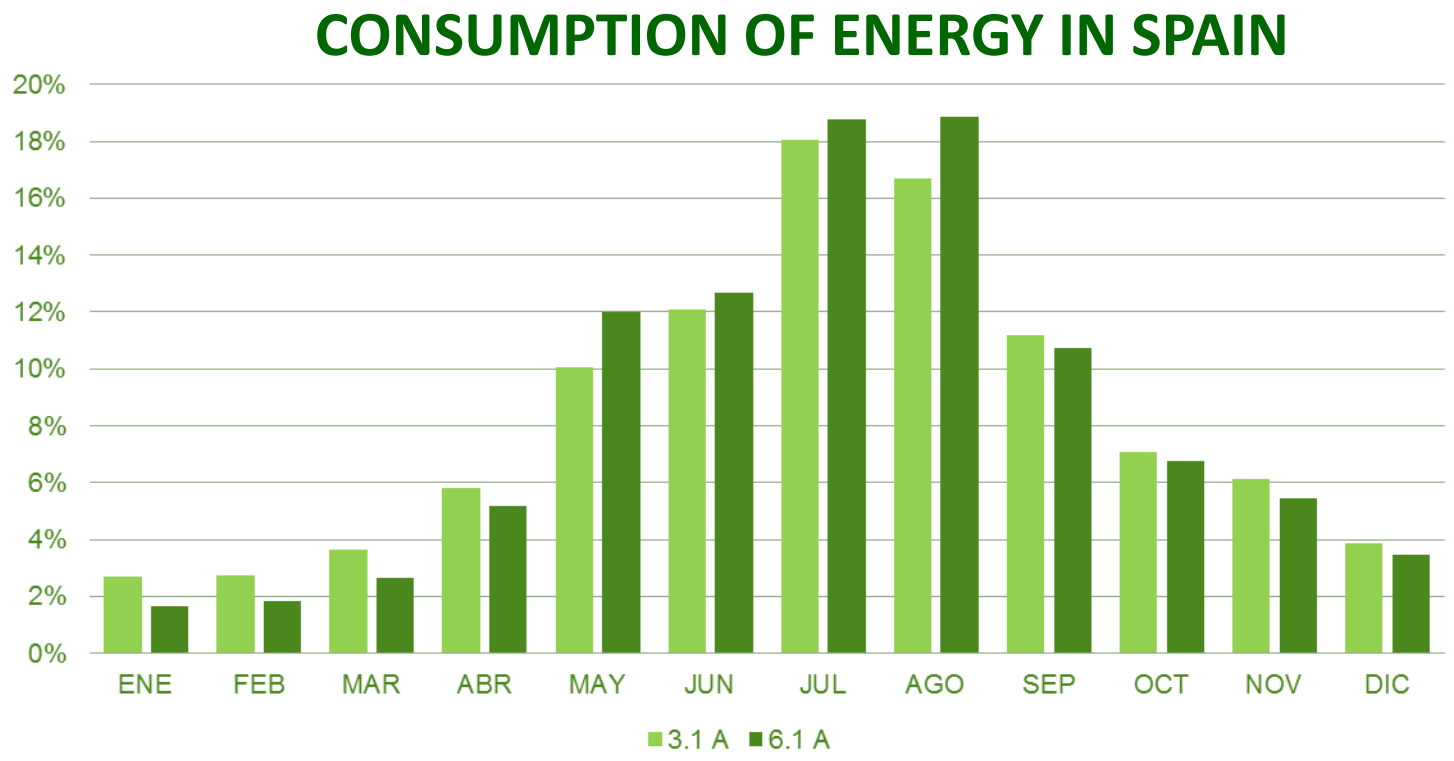
Evolution of Spanish farmers revenue (1190-2009)



Source: Anuario Estadística , MMARM .

HIGHLIGHTS

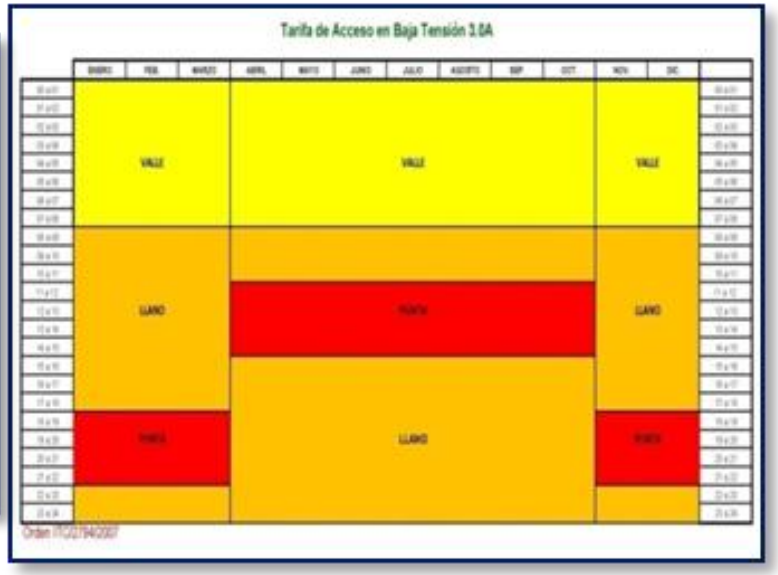
WHAT'S UP WITH ENERGY?



70 % from May to Setember
30 % from January-April and October to December

Source:Iberdrolal Generación SAU.

HIGHLIGHTS



- Electrical tariffs are different during the day, they are grouped on: peak, medium, low.
- The power requirements hired at the electrical company is high.
- The cost of the power term is paid all year long although only pumping is concentrated in five months

HIGHLIGHTS

Regional Energy Agencies develop AUDITS (http://www.idae.es/index.php/mod.pags/mem.detalle/relcategoria.1034/id.93/relmenu.55) for the improvement of the energy efficiency in irrigated areas

Energy Efficiency regards with the reduction in energy consumption while **Economical Efficiency** regards with the lowest energy cost for the same energy consumption

Energy Efficiency might improve by enhancing the design, operation and management of the irrigation systems network

Economical Efficiency might improve by enhancing the terms of the contract with the electrical supplier

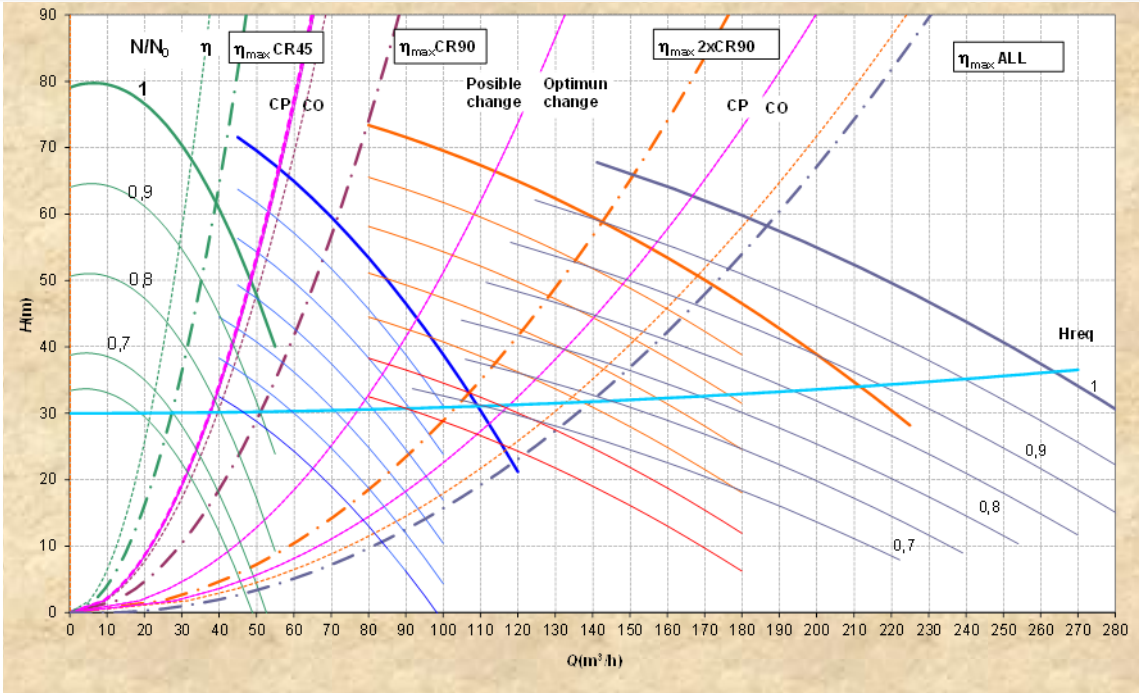
HIGHLIGHTS

Energy audits in Water Users Associations (WUA) in Spain:

- Assess the energy efficiency in WUA (adequacy in the design of the pumping system components and their management)
- Give a grade to the WUE assessing its energy efficiency
- Propose measures to reduce the energy consumption and, therefore, the operation cost

CHALLENGES

Optimization of the design, operation and regulation of pumping systems

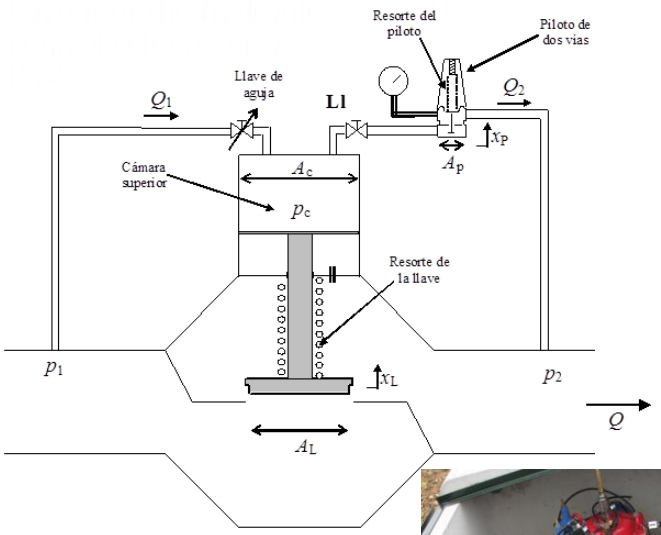


Source: Cabañas (2008).

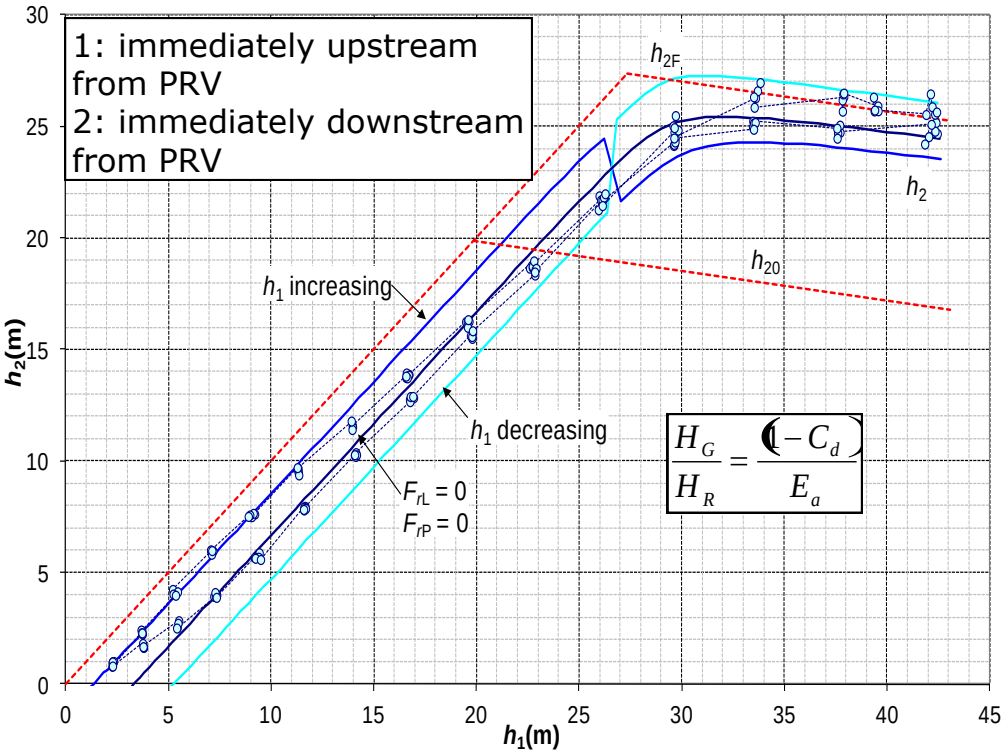
Develop criteria for a proper design, operation and regulation of pumps in pumping station taking into consideration energy efficiency.

CHALLENGES

Proper operation, regulation and maintenance of hydraulic valves



Hydrant in the field



Source: Sánchez (2012).

CHALLENGES

Optimal operation of collective irrigation water networks

- Several user friendly computer models analyzing hydraulic networks:most commonly used for irrigation networks are: EPANET (Rossman, 2001), COPAM (Lamaddalena), and Sagardoy, 2000), and GESTAR (Aliod et al., 1997).
- The calibrated hydraulic model can be used to provide information about the hydraulic behaviour of the network for each possible loading condition (scenario), and can be a useful tool for solving network management problems.

CHALLENGES

MANAGEMENT OF PRESSURIZED IRRIGATION NETWORKS

- Water orders allocated and executed for optimizing water productivity and energy cost: genetic algorithms, dynamic calculation
- Optimum sectoring depending on the network topology and monthly water demand. Number and arrangement of operating sectors would be different during the irrigation season according to water demand variability.
  - Accurate estimation of crop water demands and irrigation practices
- The analysis and control of critical points improve network operation by saving energy

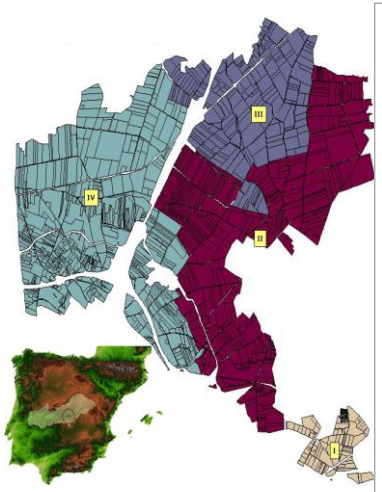
CHALLENGES

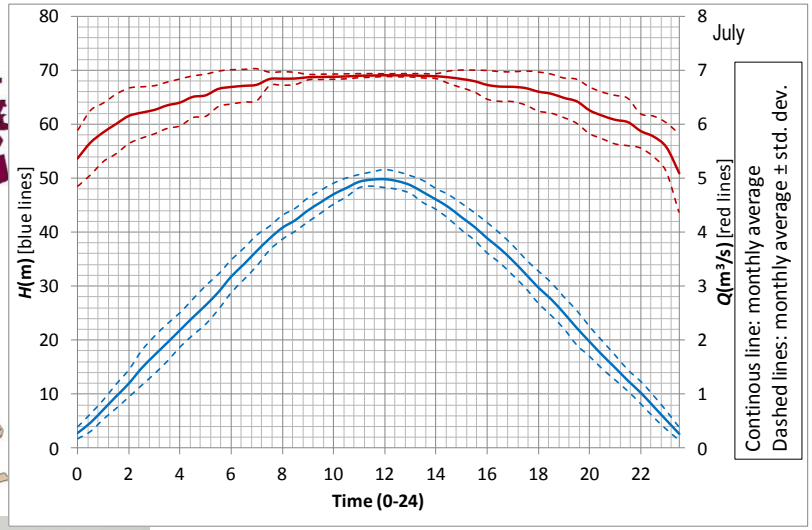
Optimize the Design, operation and management of irrigation systems in plot

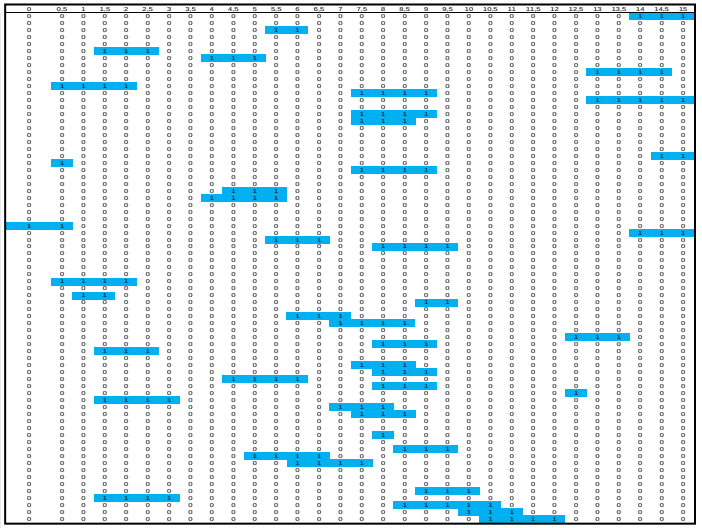
- high effect on the performance of the irrigation systems in plot of the pressure variations at hydrant level (Daccache et al. (2010).

CHALLENGES

Dynamic simulation







24 hour period simulation of operation for on-demand hydrants (blue=open).

Source:Sánchez et al. 2012.

- Simulation of different global (cropping patterns, irrigation operation,...) strategies performance on energy balance in irrigated districts.
- Determination of key factors for improving energy balance

CHALLENGES

MANAGEMENT OF PRESSURIZED IRRIGATION NETWORKS

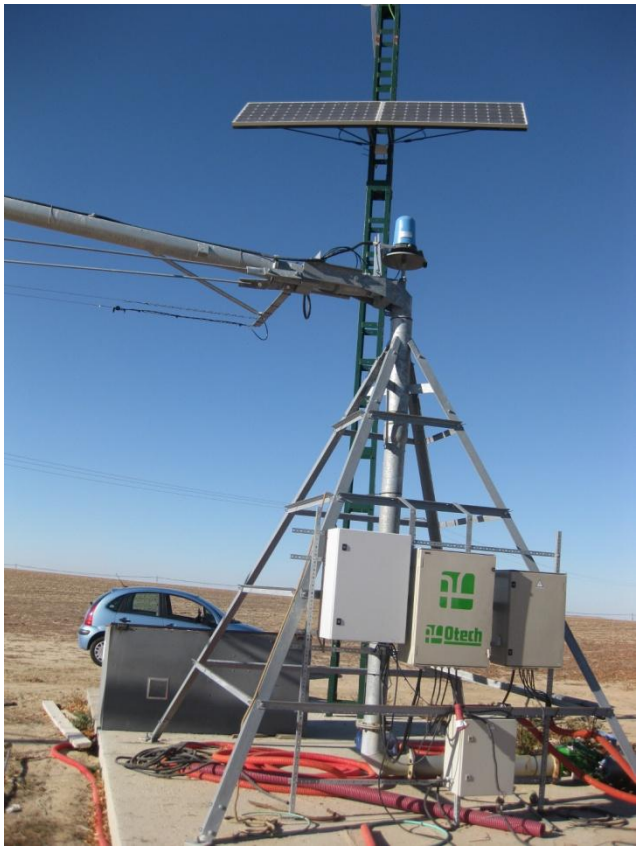
Determine the energy efficiency of pumping stations (Methodology developed by Abadía et al. 2008)

Fix the power term in the contract with the electrical supplier attending the real demanding irrigation requirements

CHALLENGUES

Use of renewable energy sources:

- ✓solar panels
- ✓windmills



REFERENCES


Thank you very much
for your attention